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THE HEALTH HAZARD OF THE MOTORCYCLE

by

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INTRODUCTION

In the late 1700's in France Comte de Sivrac constructed a two-wheeled vehicle called the célérifère. His machine consisted of a wooden bar with a padded saddle suspended by two wheels. It was propelled by the driver's pushing on the ground with his feet, and could not be steered. Baron von Drais in 1816 revised this design by mounting the front wheel on a movable fork as a steering apparatus. Shortly thereafter the "Draisienne" was introduced into England and after several minor technical revisions was called the pedestrian curricle, the hobby horse or the dandy horse (1). English lithographs around 1820 depict "dandies" riding the machine. Although it became a temporary fashion, the hobby horse was also a subject of ridicule and satire. In 1819 Keats called it "the nothing of the day" (2). A cartoon of 1818 illustrated a fancied "Velocipedraisiavaporianna" which cynically suggested a steam-driven hobby horse. This satirical picture of the ultimate impracticality appeared to be the first published idea of the motorcycle.

The cycle industry began in France about 1860 when Pierre and Ernest Michaux began to manufacture a front wheel pedal-driven bicycle called the vélocipide, which gained a rapid popular acceptance. In 1869 the first bicycling book published in the United States extolled the speed, practical applications and pure enjoyment of the revolutionary form of transportation, but also noted the "bruised elbows and scraped knees" and the "perpetual terror of...rolling and tumbling" (3).

Sylvester H. Roper of Roxbury, Mass., constructed a steam-driven velocipede in 1869. The machine was demonstrated at fairs and circuses in New England for several years, and billed as "...a perfect triumph in mechanism. It can be driven up any hill, and will outspeed any horse in the world" (4).

Attempts to eliminate the problems of excessive weight, instability, mechanical disadvantage and discomfort to the driver of the velocipede resulted in diversified revisions of cycle design and engineering over the

next several decades. Motorized versions of some of these new models were tried. In 1880 Parkins and Bateman in England successfully operated a steam-powered tricycle. L.D. Copeland of Philadelphia in 1885 modified America's popular Starr bicycle with a 1 cylinder steam engine and boiler, and several years later devised a steam-driven tricycle which he began to manufacture. He established the Moto-cycle Manufacturing Company, a business venture which proved to be an economic failure.

The two essential ingredients for a feasible motorcycle were not available until 1885, and were not combined successfully until the turn of the century. The first of these was the development of the safety bicycle, a vehicle which was driven by a chain extending from the pedals below the rider to the back wheel. The wheels of the safety bicycle were of equal size unlike the "ordinary" bicycle which featured a large front wheel, or the Starr bicycle with its large rear wheel. The second ingredient was the development of the light, high-speed internal combustion engine (2).

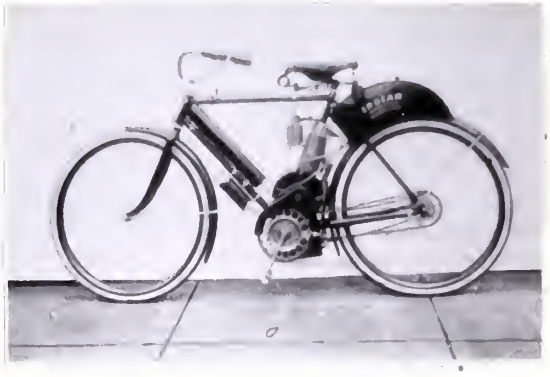
Although Gottlieb Daimler, one of the founders of the Mercedes-Benz Company, experimented with a cycle driven by a gasoline engine in Germany in 1885, the first successful commercial production of motorcycles did not begin until about 1900.

By that time engineering achievements such as light weight frames, speed gears, pneumatic tires, stronger and lighter wheels, coaster brakes and more comfortable seats had been incorporated into safety bicycle construction. Bicycle firms began to produce gasoline engine powered bicycles. Among the first manufacturers were B.S.A. and Triumph Companies of Great Britain. In this country the Hendee Manufacturing Company of Springfield, Mass., produced the first Indian Motorcycle in 1902 (4). Other early American producers included the Harley-Davidson Motor Company and Cleveland Motorcycle Company whose models were quite popular by World War I.

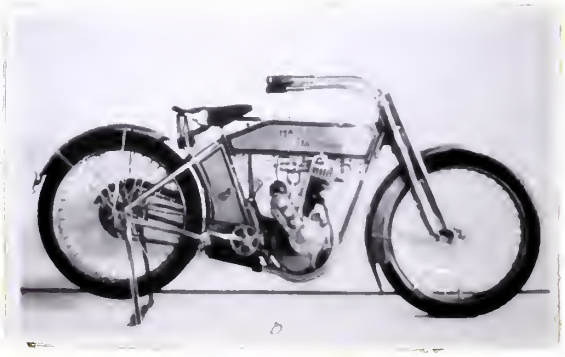
EARLY AMERICAN MOTORCYCLES

Steam-operated velocipede
S.H. Roper, 1869

Indian Motorcycle
1902



Harley-Davidson Motorcycle
1913



By 1920 motorcycles were not an uncommon form of transportation. In Connecticut, for example, there were 4305 motorcycles registered that year (compare to Connecticut's 1962 registration of 5762). Depression hurt motorcycle manufacture, and after World War II motorcycle popularity declined in the United States. The contrary happened in Europe after the war, where cheap transportation was in demand and gasoline was scarce.

As shown in Table I below, until 1955 the numbers of registered cycles in the United States declined (5).

TABLE I

	Registered motorcycles	Decrease from year before
1949	478,851	------
1950	453,874	24,977
1951	429,699	24,175
1952	417,578	12,121
1953	411,835	5,743
1954	404,772	7,063

The reason for the decrease was in large part due to the poor image the motorcycle driver had acquired after the war. The antithesis of American middle-class conformity, he was a jobless, homeless, irresponsible hedonistic rebel. His black leather jacket, boots, sun goggles, motorcycle hat, tatoos and personal unkemptness created an awesome picture. The 1952 Stanley Kramer movie, "The Wild One", which starred actor Marlon Brando as a motorcycle gang leader, popularized this image.

A reversal in the trends of decreasing motorcycle registrations in this country occurred in the later 1950's. Image-making again probably accounted for this trend. Holleywood presented lightweight motorcycles and motor-scooters as a fashionable form of transportation among European cosmopolitans. The Academy Award-winning movie "Roman Holiday" made the image acceptable even for women. Table II illustrates the growth of motorcycle registrations

in the period 1955-1960 (5).

TABLE II

	Registered motorcycles	Increase from year before
1955	412,377	7,605
1956	431,494	19,117
1957	468,816	37,322
1958	521,332	52,516
1959	561,310	44,020
1960	574,080	8,728

The record of motorcycle registrations in the United States after 1960 has shown a dramatic annual growth in the numbers of cycles owned. Table III below lists the registrations for the first half of this decade, for which these statistics are presently available (5).

TABLE III

	Registered motorcycles	Increase from year before
1961	595,669	21,589
1962	660,400	64,731
1963	786,318	125,918
1964	984,760	198,966
1965	1,380,726	395,966

The recent popularity of motorcycles is in large part due to the successful marketing of imported lightweight motorcycles. Low-cost Japanese models have dominated the American market. In 1966 the Honda Company was reported to control an estimated 70% of motorcycle sales in the United States (6).

In 1960 only 2548 Hondas were sold in this country. During the next five years this company undertook an expensive advertizing campaign to establish firmly a favorable image for motorcycles and dispell forever the hoodlum image that had existed a decade before. The company spent $8 million to sell one idea: "You meet the nicest people on a Honda." Special effort was made to sell the product to the college-age consumer, both via network television and college newspaper ads (6).

These campaigns were highly successful. In 1965 Honda sold 267,640

cycles. Honda's total sales in the United States from June 30, 1965 to June 30, 1966, amounted to $106,029,000. The company claimed that one important cause for the sales boom was that women, particularly of college age, bought Hondas, and that the numbers of female cyclists had more than doubled between 1964 and 1966 (6).

Articles in popular newspapers and magazines reinforced the respectable image of the motorcycle. In 1965 Esquire Magazine featured several motorcycle stories, including a description of a Manhattan Executive's Motorcycle Club, and a story entitled "The Upward Mobility of the Motorcycle", which constructed a "status structure" among the various kinds of motorcycles marketed (7). In 1966, the Sunday New York Times published a feature called "Putt-Putts in Bermuda" which discussed the fun of motorcycling for the young cosmopolitan (8).

Motorcycling thus became fashionable among young adults. The expectation of fun and prestige of owning a motorcycle accounts for the majority of first purchases (9), and this expectation is largely the result of the effective publicity. The additional advantages of ownership include the relatively low initial cost of about $400, the inexpensive operating costs, maneuverability in traffic and easy parking.

The increasing popularity of motorcycles has produced greater numbers of motorcycle accidents in this country. Many of these accidents have resulted in injury or fatality to the cyclist. During the past several years there has been growing alarm over the health hazard of the motorcycle, which has been called the deadliest vehicle on the nation's highways (10). The recent national fatality statistics are striking, as shown in Table IV (5).

ADVERTISEMENT FROM LIFE MAGAZINE, 1966

You meet the nicest people on a Honda.

HONDA

TABLE IV

	Deaths	Death rate per 100,000 population
1961	697	0.4
1962	759	0.4
1963	882	0.5
1964	1,118	0.6
1965	1,580	0.8

The dangers involved in motorcycling are reflected in the expensive insurance rates, which are necessarily based on the actuarial statistics. In New York State, for example, most insurance companies will not insure motorcycles because of the poor risk (11). These companies point to greater skill involved in motorcycle driving, and the vulnerability of the unpackaged driver to injury. The insurance policies available to cyclists frequently do not insure passengers, do not cover any operator other than the owner-driver for damages or injuries he may cause, do not apply when the cyclist is engaged in speeding or riding contests, and will not cover expenses for medical payments for injuries to the operator (11).

To draw conclusions about the nature of the risk involved in operating a motorcycle is an extremely difficult task. The major difficulty lies in the rigorous definition of the population at risk. In order to understand who is likely to have a motorcycle accident, and why, a great number of nearly indeterminate factors must be ascertained. Among these unknowns are the skill of the driver, the specific mechanical and safety devices on a particular vehicle, the previous experience of the operator and not least the psychologic motivations of the driver.

This study was not intended to provide definitive statements about the dangers of motorcycling. It was, however, designed to describe the nature of the present motorcycle problem by reviewing in detail the most recent available record of accidents in Connecticut, and, where pertinent, comparing motorcycle accidents to accidents of other motor vehicles. Various trends or patterns

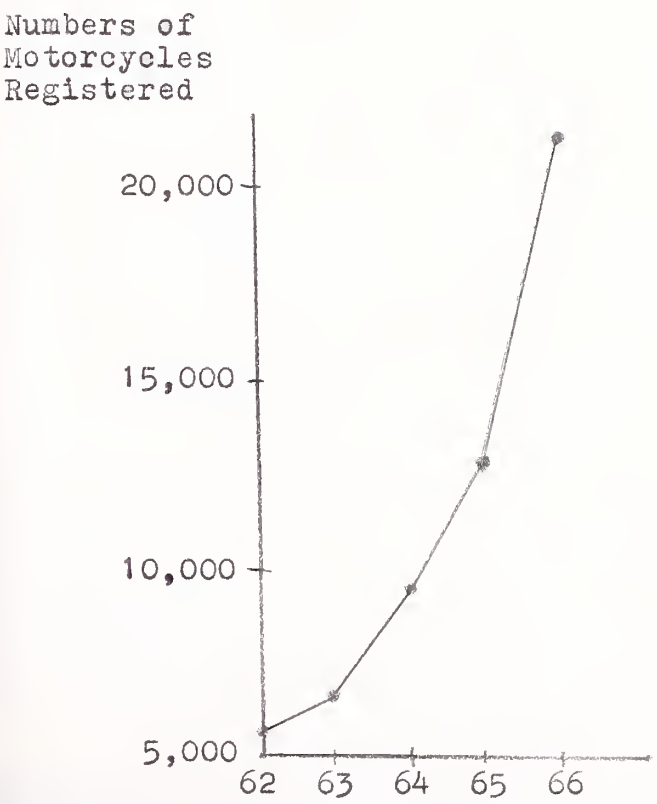
for motorcycle accidents emerged from this review, and these are discussed. In addition, a sample of the kinds of injuries from motorcycle accidents are presented. The findings in Connecticut are compared to previously published motorcycle research. Hopefully, the information provided in this study will lead to a reasonably accurate understanding of the present situation, without which a satisfactory solution to the current health problem of motorcycling cannot be obtained.

A DESCRIPTIVE ANALYSIS OF THE MOTORCYCLE PROBLEM IN CONNECTICUT

Motorcycles in Connecticut, 1962-1966

During this time period motorcycle registrations in this state increased 362%. The increase was accompanied by a 211% rise in motorcycles involved in accidents, a 232% rise in motorcycles having injury accidents and a 243% increase in the number of these vehicles causing fatality. The following graphs illustrate the changes. (See Appendix, Table I.)

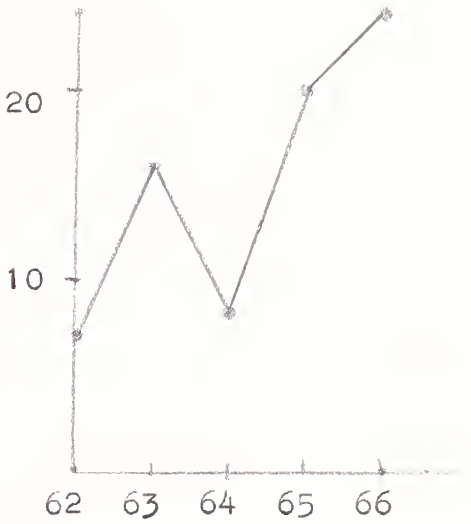
GRAPH I



GRAPH IIa

GRAPH IIb

Numbers of Motorcycles involved in fatal accidents



These increases may be compared to the same statistics for automobiles during this period. Registrations rose 18%, cars having accidents rose 7.6%, those having injury accidents increased 14% and cars involved in fatal accidents increased 35%.

Connecticut has, therefore, experienced the same explosive growth in motorcycle registrations and accidents as reported in the national statistics.

Comparative Incidence and Severity of Motorcycle Accidents

The total number of registered motor vehicles in Connecticut in 1966 was 1,593,860. Of this total 21,673 were motorcycles, or 1.36%.

113,669 vehicles were involved in accidents, and 1174, 0.97% of the total, were motorcycles.

39,112 vehicles took part in injury or fatal accidents. Of this group, 1004 were motorcycles, or 2.57%.

Thus motorcycles, 1.36% of all motor vehicles, constituted only 0.97% of the vehicles involved in accidents, but 2.57% of the vehicles whose accidents caused injury or fatality.

Of the total registered motorcycles, 5.44% were involved in accidents. Of the total for all other motor vehicles, 7.12% had mishaps. However, 85.5% of the motorcycles having accidents caused injury or fatality, compared to 30% for all other vehicles.

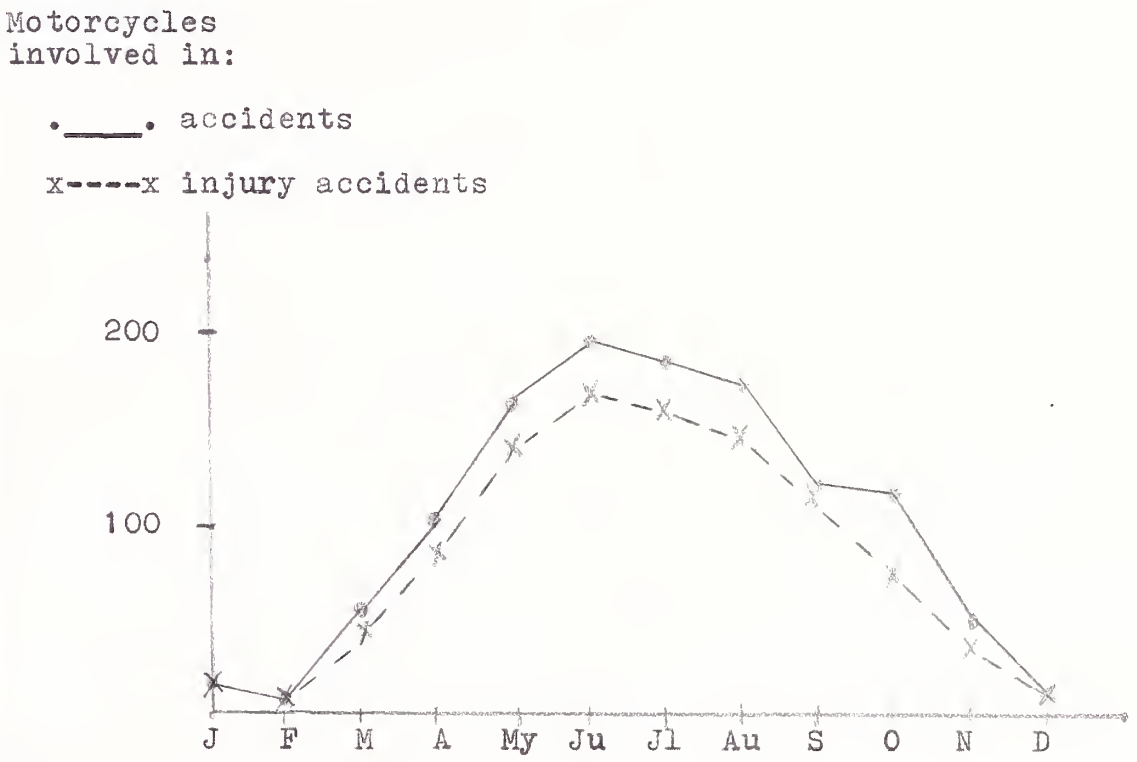
In 1966, therefore, motorcycles had proportionately fewer total accidents than other motor vehicles, but motorcycle accidents caused relatively more injuries and fatalities.

The 1174 motorcycles were involved in 1152 separate accidents; 960 of these accidents produced personal injury, and 23 resulted in fatality. A total of 1180 persons were injured and 24 were killed in these mishaps.

Monthly Distribution of Motorcycle Accidents

1966 motorcycle accidents, and injury and death resulting therefrom, showed a predominance during the warm months of the year. This pattern is shown in Graphs III and IV. (See Appendix, Table II.)

GRAPH III



GRAPH IV

Motorcycles involved in
Fatal accidents

June had the most accidents, 17% of the total, and the most injury and fatal accidents, 17.4%.

62% of all motorcycle accidents occurred during May, June, July and August. 63.4% of the injury and fatal mishaps took place during this time.

82.5% of accidents in those four months resulted in injury or death. Although the winter months of January, February and December accounted only for 2.2% of accidents, all of these accidents caused injury, and none were fatal.

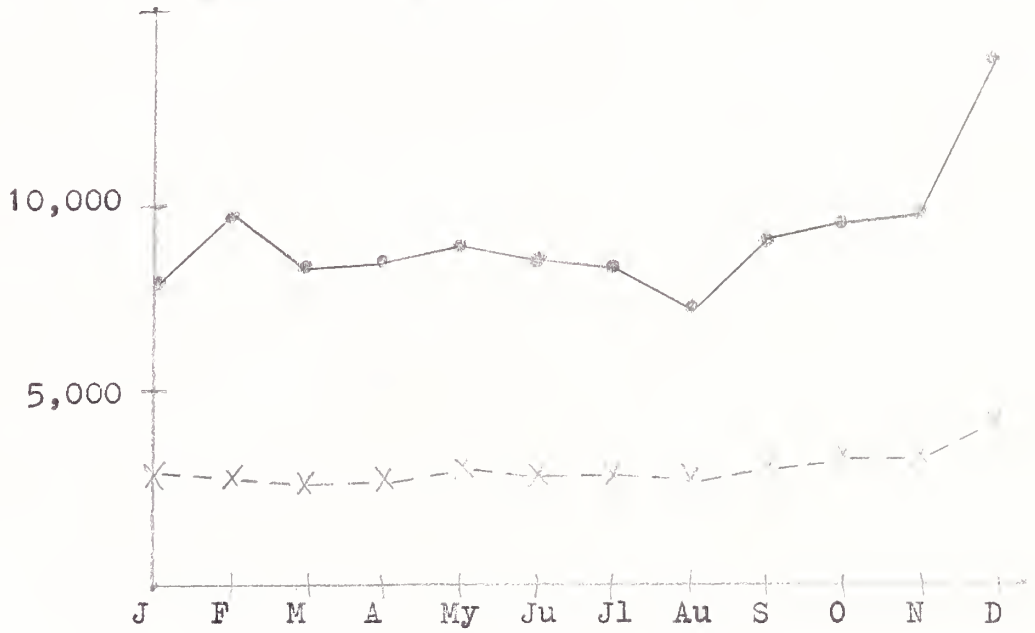
The monthly distribution of motorcycle accidents was distinct from the incidence for all other motor vehicles. For this group December had the most total, injury and fatal accidents. Graphs V and VI illustrate the incidence of accidents for other motor vehicles. (See Appendix, Table III).

GRAPH V

Other Motor Vehicles
involved in:

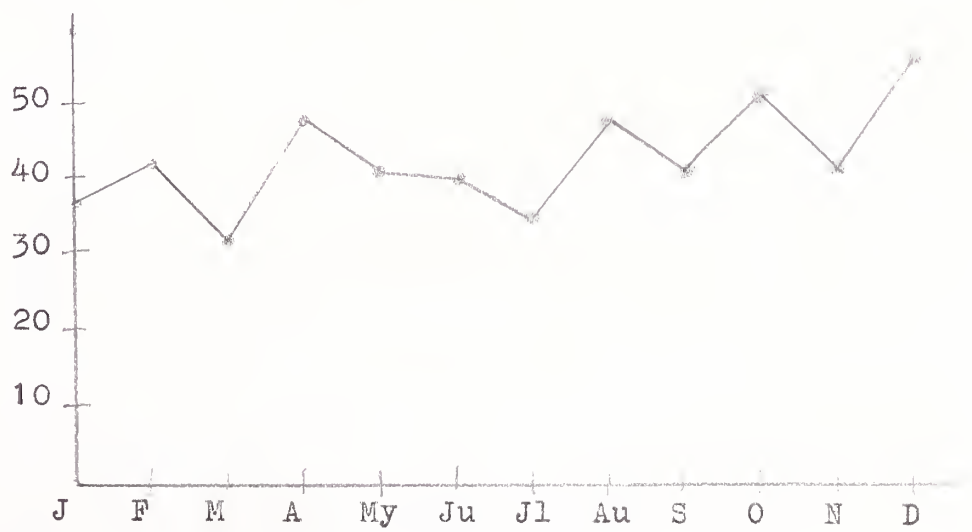
._____. accidents

x------x injury accidents



GRAPH VI

Other Motor Vehicles
involved in
Fatal accidents



Type of Accident

(See Appendix, Tables IV-VIII.)

61% of the 1152 accidents with motorcycles involved another motor vehicle. 10 persons died in 10 such accidents; 715 were injured in 705 accidents. These persons represent 41.8% of the total killed and 61% of the total injured from motorcycle accidents in 1966.

48.5% of the 715 injured persons had relatively serious trauma. About 61% of the seriously injured from all types of motorcycle accidents resulted from accidents with other motor vehicles.

Of the total motorcycle-other motor vehicle accidents 35% involved collisions at intersections. 35% of the fatal and 35% of the injury accidents occurred this way. More accidents took place between vehicles going in opposite directions (128) than in the same direction (106). 97% of the accidents in which the vehicles were going in opposite directions resulted in injury, compared to 76% of those accidents in which the motorcycle and other motor vehicle moved in the same direction. Of the fatal accidents with another vehicle at intersections, all 6 involved the vehicles traveling in opposite directions. The great majority of accidents with other motor vehicles in opposite directions at intersections involved one turning left. (See Appendix, Table V.)

Accidents involving another motor vehicle not at intersections accounted for 26% of the 1152 motorcycle mishaps. 17% of the fatal and 23% of the injury accidents were of this type. Unlike at intersections, more accidents occurred with the vehicles heading in the same direction (51) than in opposite directions (37). Both produced 33 injury accidents, but one fatality was recorded in the group proceeding in the same direction. Of the total accidents with another vehicle not at an intersection, nearly half were at driveways or alley ways. (See Appendix, Table VI.)

1.06% of the 1152 motorcycle accidents occurred by the motorcycle running off the road. This 1.06% of accidents accounted for 37% of the fatalities, 12.6% of the seriously injured and 9.7% of the total injured. Of the 122 persons injured from this type of accident, 59% had serious injuries, the largest proportion of serious injury for any type of accident. (See Appendix, Tables IV and VIII.)

29 persons suffered injuries from 21 motorcycle accidents with pedestrians. About half of the pedestrians injured were not crossing at intersections. Nine of the 29, or 31% of the injured parties, had relatively minor trauma, and comprized the highest percentage of non-serious injury for any type of motorcycle accident.

Of note is that animals were involved in 44 motorcycle accidents and injury to 48 persons, but no fatality.

Accident Conditions

1. Weather: 90% of the 1152 accidents occurred in clear weather. 91% of the fatal accidents and 91% of the injury accidents also took place in the absence of rain, fog or snow. Rain was present in only 4.8% of all accidents, 4.3% of fatal accidents and 4.8% of the injury accidents. The numbers of accidents in fog or in snow were less than 1% of the totals. (See Appendix, Table IX.)

71% of the non-motorcycle accidents, 77% of the fatal and 74% of the injury mishaps occurred in clear weather. Rain was present in about 14% of the total, fatal and injury accidents for other motor vehicles.

2. Light: 69% of motorcycle accidents transpired in daylight. 42% of the total fatal and 70% of the injury accidents occurred in daylight.

52% of the fatal accidents took place in darkness. Darkness was present in 27% of all accidents and 26% of the injury accidents. Dawn and dusk were the times of few motorcycle accidents. (See Appendix, Table X.)

58.7% of accidents with other motor vehicles occurred in daylight, as did 38.1% of the fatal and 55.5% of the injury accidents. Darkness was present in 58.1% fatal, 36.1% injury and 36.3% of the total non-motorcycle traffic accidents.

3. Road Surface: A dry road surface was present in 90% of all motorcycle accidents, 96% of all fatal motorcycle accidents and 90% of the injury accidents. Accidents on wet surfaces comprised 6.9% of the total, 4.3% of fatal and 7.1% of injury accidents. (See Appendix, Table XI.) For accidents not involving motorcycles, 67.1% of the total occurred on dry roads, 74.9% of the fatal and 66.1% of the injury. Nearly 20% of the total, fatal and injury accidents took place on wet roads. About 10% of the non-motorcycle mishaps occurred on snow or ice.

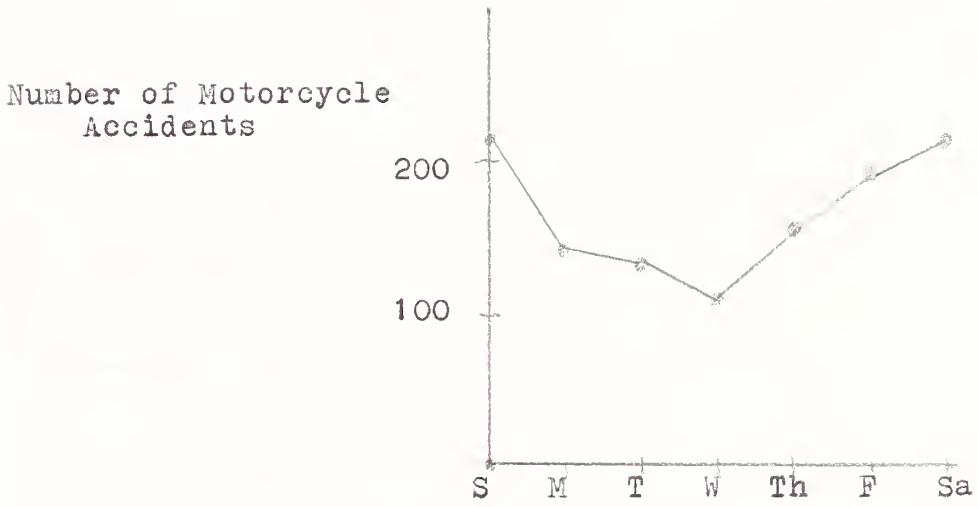
Location

The great majority of motorcycle accidents occurred in relatively well-populated areas. 86% of all the accidents took place near apartments, stores, factories or homes. 83% of the fatal mishaps and 86% of injury accidents took place at these locations. (See Appendix, Table XIII.)

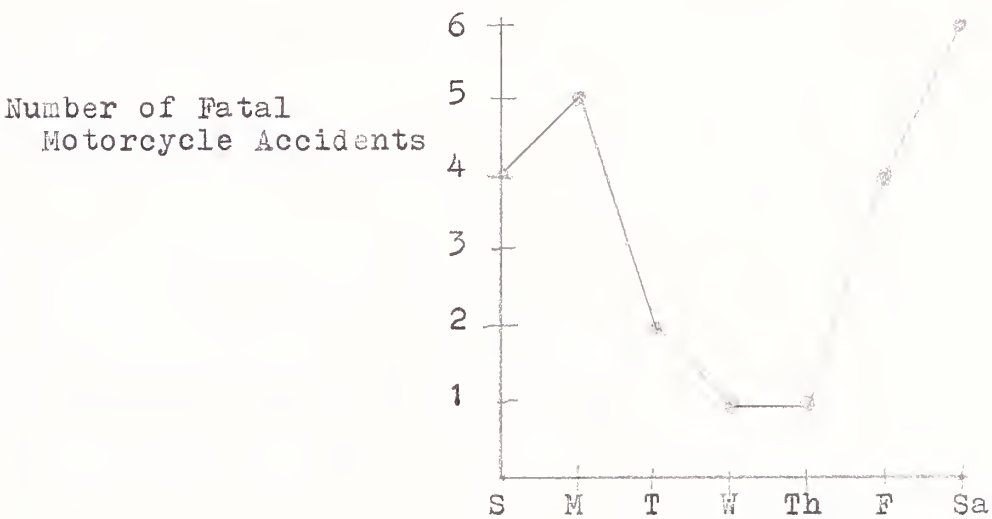
Day of Week

36% of motorcycle accidents in 1966 took place on Saturday and Sunday. 43% of the fatal accidents happened on these days. Wednesday had the fewest total and fatal accidents. Graphs VII and VIII illustrate the incidence of accidents by day of week. (See Appendix, Table XIV.)

GRAPH VII



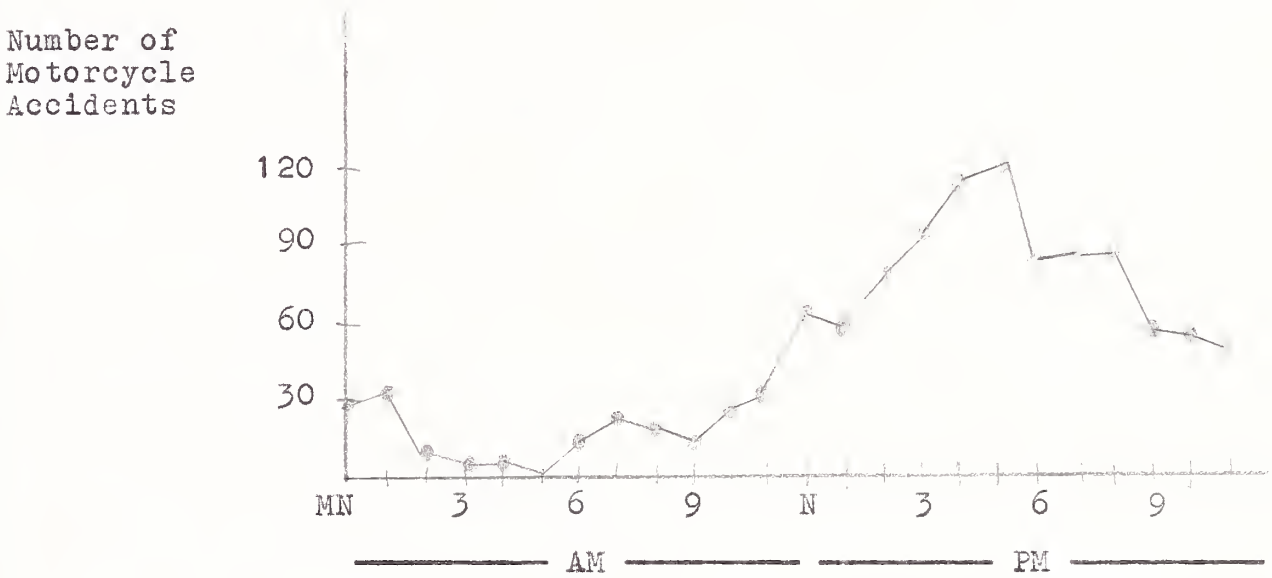
GRAPH VIII



Time of the Day

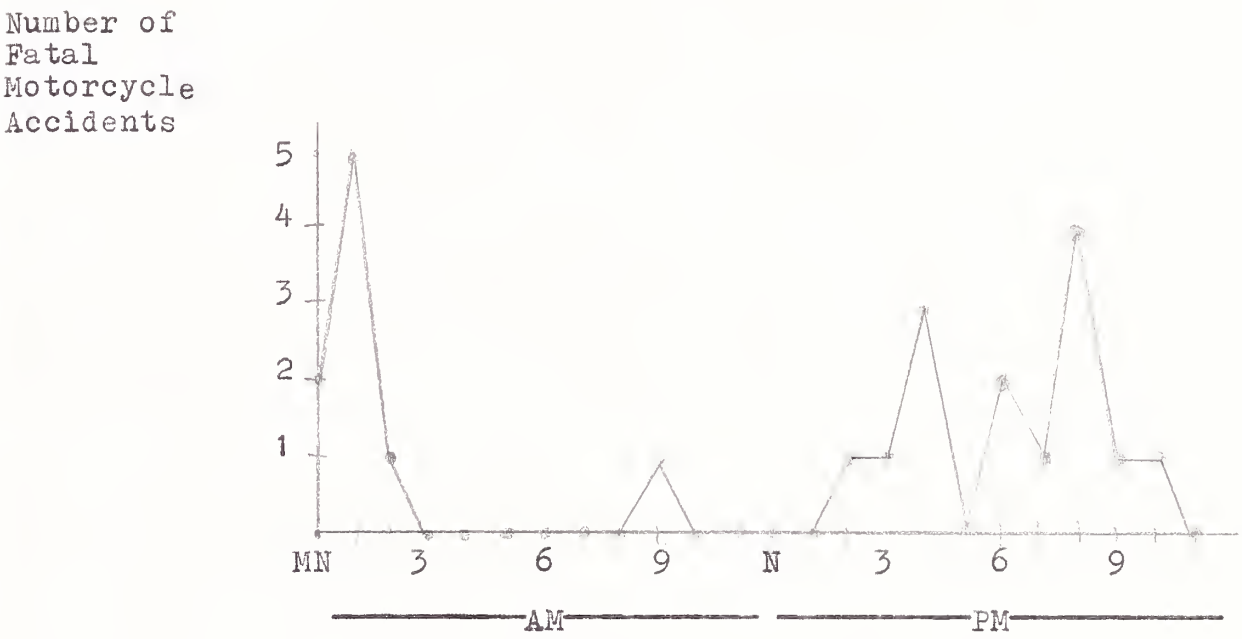
As discussed above, most motorcycle accidents occurred in daylight. The six-hour interval between 3 PM and 9 PM accounted for 50.7% of the total mishaps, and the peak hours were 4-5 PM and 5-6 PM. These findings are shown in Graph IX. (See Appendix, Table XV.)

GRAPH IX



48% of the fatal motorcycle accidents occurred during the six-hour period from 3 PM to 9 PM. However, the peak hour for fatal mishaps was 1-2 AM. The hourly incidence of fatal accidents from 1966 is shown in Graph X.

GRAPH X



Type of Road

City streets were the sites of 57% of the fatal and 81% of all motorcycle accidents in 1966. Although only 16.5% of motorcycle accidents occurred on state and U.S. routes, 43% of the fatal mishaps took place on these roads.

Limited access highways had no fatal motorcycle accidents and only 23 of the total 1152 accidents in 1966. (See Appendix, Table XVI.)

Contributing Circumstances

In 72% of all the accidents, 72% of the injury accidents and 91% of the fatal accidents some contributing circumstance was cited. These are specified in Table XVII, Appendix. Speeding was implicated in 6 of the 23 fatal accidents. Failure to yield the right of way was described in 15% of accidents and injury accidents, and 1 fatal mishap. Drinking and mechanical failures were features of very few accidents, although drinking

was implicated in two of the fatals. Relative to the numbers of fatal accidents, drinking was a causative factor in over twice as many non-motorcycle mishaps.

Driver

The statistics described below refer to the drivers of motorcycles or other motor vehicles involved in an accident with a motorcycle.

1. Age: The ages of the drivers showed a marked predominance in the 16 to 24 year old age group. About 60% of the fatal, injury and total mishaps with motorcycles involved drivers of this age group. (See Appendix, Table XVIII.)

For all traffic accidents excluding motorcycle accidents, only 29.9% of the drivers were 16 to 24 years old. For fatal accidents, 31% were of this age group, as were 31.9% of the drivers in injury accidents.

2. Sex: About 85% of the drivers in the total 1152 accidents and 960 injury accidents were males. 94% of the drivers involved in fatal accidents were males. (See Appendix, Table XIX.)

In the non-motorcycle accidents, male drivers were 66.9% of the total. In fatal non-motorcycle accidents, 77% of drivers were male. Injury accidents of this group had 69.1% male operators.

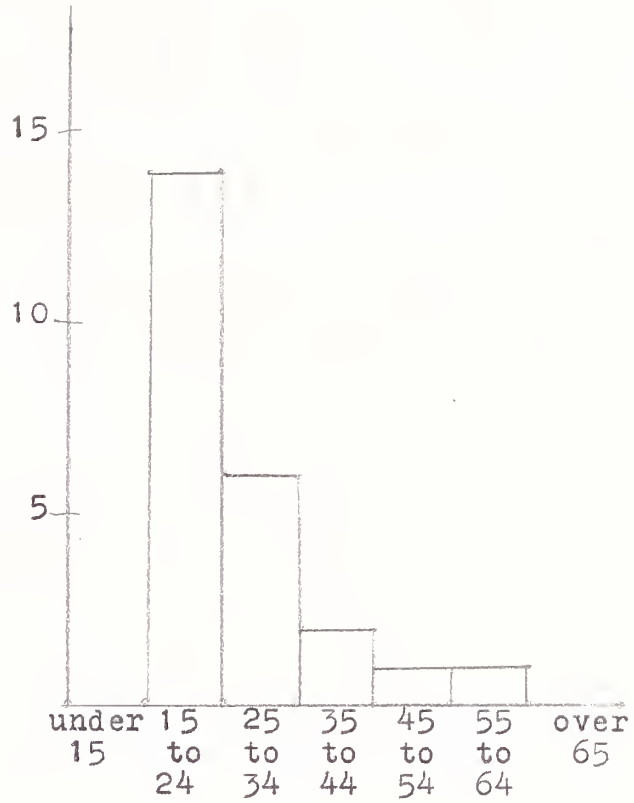
3. Residence: Most of the drivers were local residents, as indicated in Table XX, Appendix.

Ages of the Casualties

14 of the 24 fatalities were between the ages of 15 and 24 years. 897 of 1180 persons injured, or 76%, fell within this age group. Graphs XI and XII indicate these age distributions. (See Appendix, Table XXI.)

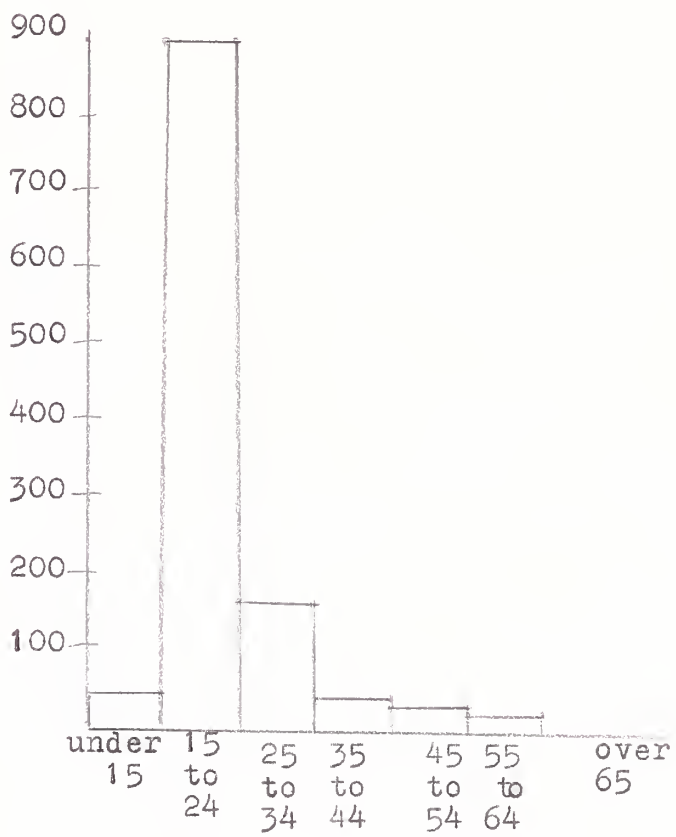
GRAPH XI

Number of
Persons Killed



GRAPH XII

Number of
Persons Injured



22 of the 24 persons killed and 87% of the injured were males. (See Appendix, Table XXI.)

Highway accidents in 1966 which did not involve motorcycles resulted in 25.9% of the killed and 33.9% of the injured to be of the age group 15 to 24 years. 72% of the total killed in these accidents were males; 57.4% of the total injured were males.

Injuries Resulting from Motorcycle Accidents

During the period February to November, 1966, the New Haven Police Department recorded 43 motorcycle accidents, all occurring within the city limits, which resulted in injury to drivers and/or passengers. According to police records 55 persons were taken for emergency treatment to the Yale-New Haven Hospital or the Hospital of St. Raphael. These hospitals had records for 50 of this group. 37 were drivers, and 13 were passengers.

A survey was made of the injuries suffered by these 50 persons. A total of 159 separate injuries were sustained. These injuries are presented in detail in Table XXII, Appendix. The following table summarizes the findings, and the abbreviations used are as follows:

LLE = Left lower extremity

LUE = Left upper extremity

RLE = Right lower extremity

RUE = Right upper extremity

CAB = Chest, abdomen and back

P = Pelvis

LOCATION	Head	LLE	LUE	RLE	RUE	CAB	P	TOTAL
Abrasions	9	22	14	16	7	4	0	72
Lacerations	20	3	3	5	6	0	0	37
Fractures	5	7	5	0	2	1	1	21
Contusions, hematomas	1	3	3	3	1	3	1	15
Dislocations, separations	0	0	1	0	1	0	0	2
Other:								10
Cerebral concussion	8							
Epidural hematoma	1							
Broken tooth	1							
Pulmonary emboli						2		
TOTAL:	45	35	26	24	17	10	2	159

The most common injuries were abrasions, constituting 45% of the total. Lacerations were the next most common, 23%, and fractures followed with 15% of all injuries.

The head received 28% of all injuries recorded. In descending order, the incidence of injury to other parts of the body was as follows: 22% involved the left lower extremity, 16.4% the left upper extremity, 15.1% the right lower extremity, 10.7% the right upper extremity. There were relatively few injuries to the chest, abdomen, pelvis or back.

The four extremities were the site of 64% of all injuries. Of these 102 injuries, 60% were sustained on left extremities, and 40% on the right. The lower extremity injuries constitutes 58% of the total injuries to the extremities.

14 of the 21 fractures involved the extremities. 12 of the extremity fractures occurred on the left, and 7 on the left lower alone. There were

no fractures of the right lower extremity in these 50 persons.

The case histories of some of the more seriously injured persons and the one fatality are presented below.

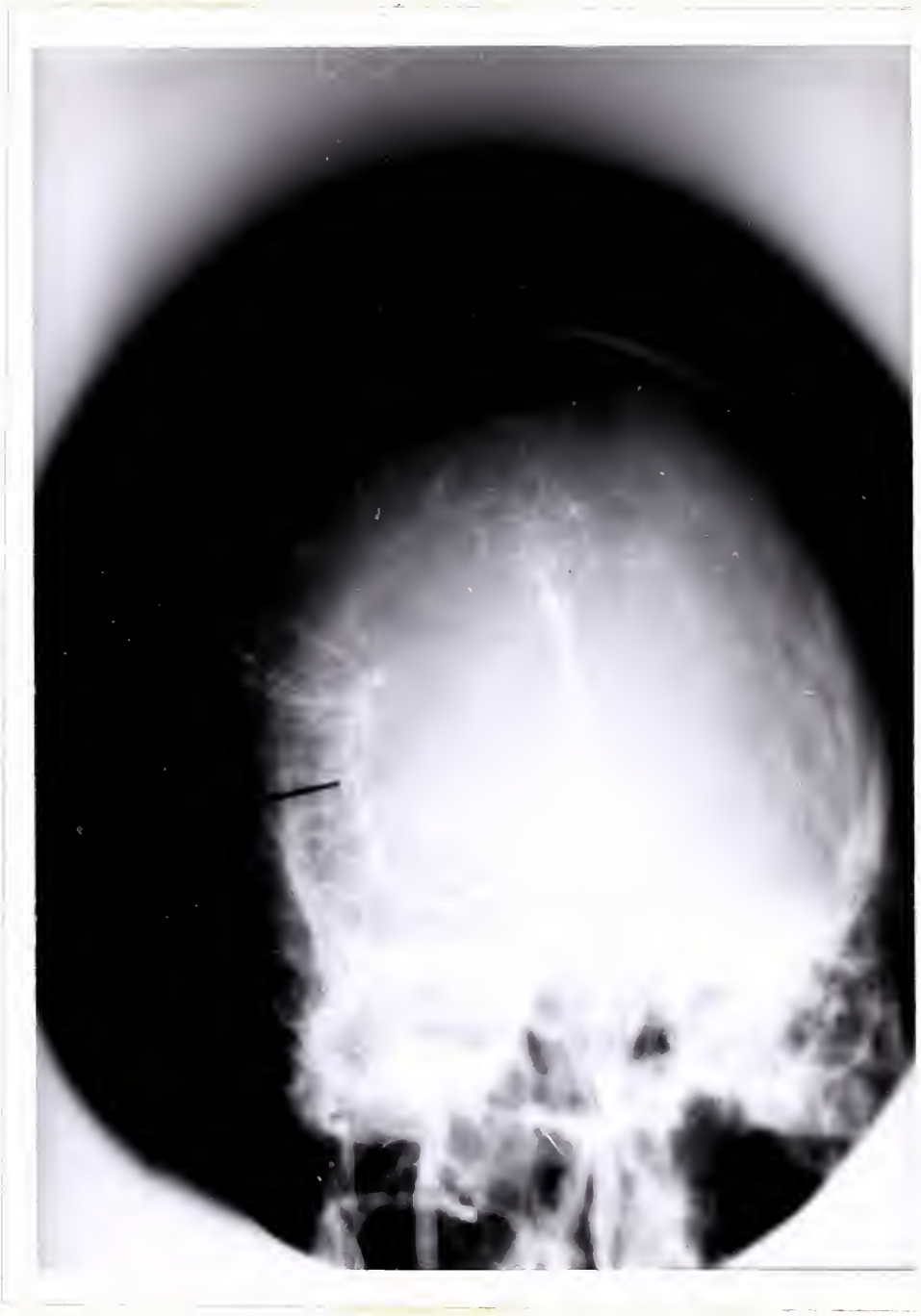
CASE I A 27 year old father of two driving a motorcycle struck a car moving in the same direction at 2:05 AM. The patient had a temporary loss of consciousness, a large laceration across the left forehead with partial avulsion of the left eyelid, partial avulsion over the left malar area, transverse fracture of the left femur at the junction of the mid- and lower thirds and fracture of the fifth left metacarpal. The neurologic exam was unremarkable. Facial lacerations were sutured and a Thomas splint applied to the left femur. 11 days after admission the femoral fracture was reduced and fixated with a Kuntscher intramedullary nail, under spinal anesthesia. On the 21st hospital day the patient developed a large skin ulcer of the left thigh, where bruised at the time of the accident, which required skin graft. On the 42nd hospital day the patient complained of left pleuritic chest pain. Chest X-rays showed increased pulmonary markings with no infiltrates or effusions. The pain was undiagnosed by the 49th hospital day, when the patient was discharged. Three days after discharge the patient returned to the emergency room with sudden chest pain, shortness of breath and sweating. Chest X-rays showed left lower lobe wedge-shaped infiltrate with associated atelectasis. Diagnosis of acute pulmonary embolus was made, and on the 11th hospital day of this admission the patient was discharged with coumadin medication.

CASE II A 19 year old college girl was a passenger on a motorcycle which hit a stone in the road, went out of control and crashed against a stone wall. The patient was unconscious for 5 minutes, was delirious and uncooperative with periods of somnolence when seen in the emergency room. There was a 5 cm. laceration over the left parietal area and an abrasion over the left hip. The patient vomited three times during the examination. On the 2nd hospital day the patient developed severe headaches and bradycardia, and vomited small amounts of blood. Skull films showed a linear fracture of the left parietal area, and fluid levels in the sphenoid and maxillary sinuses. Carotid angiogram suggested inward displacement of the middle cerebral artery. The patient on the third hospital day developed double vision and photophobia. On the 4th day the patient underwent a left temporal decompression and removal of a left epidural hematoma. A bleeding point was found in the left middle meningeal artery and coagulated. The patient was discharged on the 11th day. Follow-up after four months revealed complaints of persistent insomnia and depression. Physical exam revealed no neurologic disabilities.

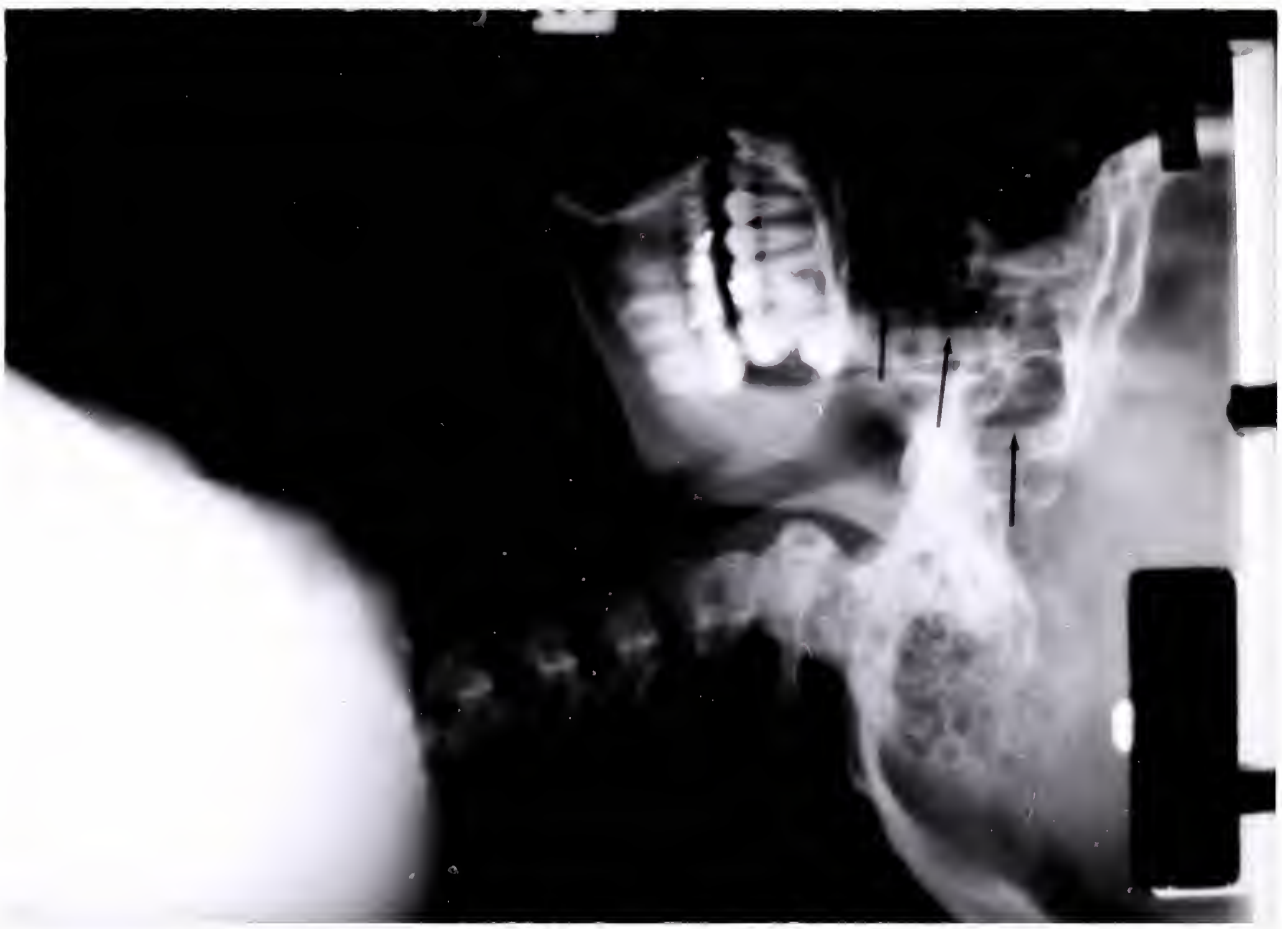
CASE III A 19 year old college student driving a motorcycle collided with a car at a city intersection at 12:25 PM. He suffered transverse fracture of the left femur at the distal third of the shaft, transverse fracture through the mid-diaphysis of the ulna, anterior fracture of the fourth right rib, fracture of the right acromial process, costochondral separation of the right third rib, laceration of the lower lip and multiple abrasions. Although the patient was wearing a helmet, X-rays showed linear frontal bone fracture, and the patient had retrograde and post-traumatic amnesia. Chest X-rays were consistent with pulmonary contusion and bilateral effusions. On the 4th hospital day the patient developed left chest pain, tachycardia, tachypnea and mild fever. Chest X-rays were consistent with bilateral lower lobe infarcts. A bloody effusion fluid was removed by thoracentesis. The clinical impression was thrombi or fat emobli in the lungs. Ulnar fracture was treated with a sugartong splint, femoral fracture with skeletal suspension traction followed by a Kuntscher intramedullary rod. The patient was discharged on the 38th hospital day with evidence of an organizing hematoma in the lower lobe of the left lung.

CASE IV A 23 year old man was a passenger of a cycle which swerved to avoid a car entering the same lane and collided head-on with another automobile at 6:10 PM. In the emergency room the patient was found completely unresponsive, and bleeding from his left ear and nose. There were no swellings or bruises on his head. The left pupil was dilated and both pupils were unreactive to light. There was no papilledema. Small abrasions were found by the right nipple and a small laceration over the right elbow. Bilateral ankle clonus was present, and there was no Babinsky sign. Skull X-rays showed biparietal fracture, on the left extending to the mastoid and petrous pyramids, on the right extending to above the petroid-mastoid suture. Fluid was seen in the sphenoid sinus. A 2 cm. shift to the left was noted by echo encephalogram. At operation a right subdural hematoma was evacuated. On the 2nd hospital day he developed decrebrate rigidity, tachycardia, hypotension and apnea. Adrenalin, isuprel and dextran restored the blood pressure transiently. The patient again developed hypotension followed by heart arrest, and expired on the second hospital day.

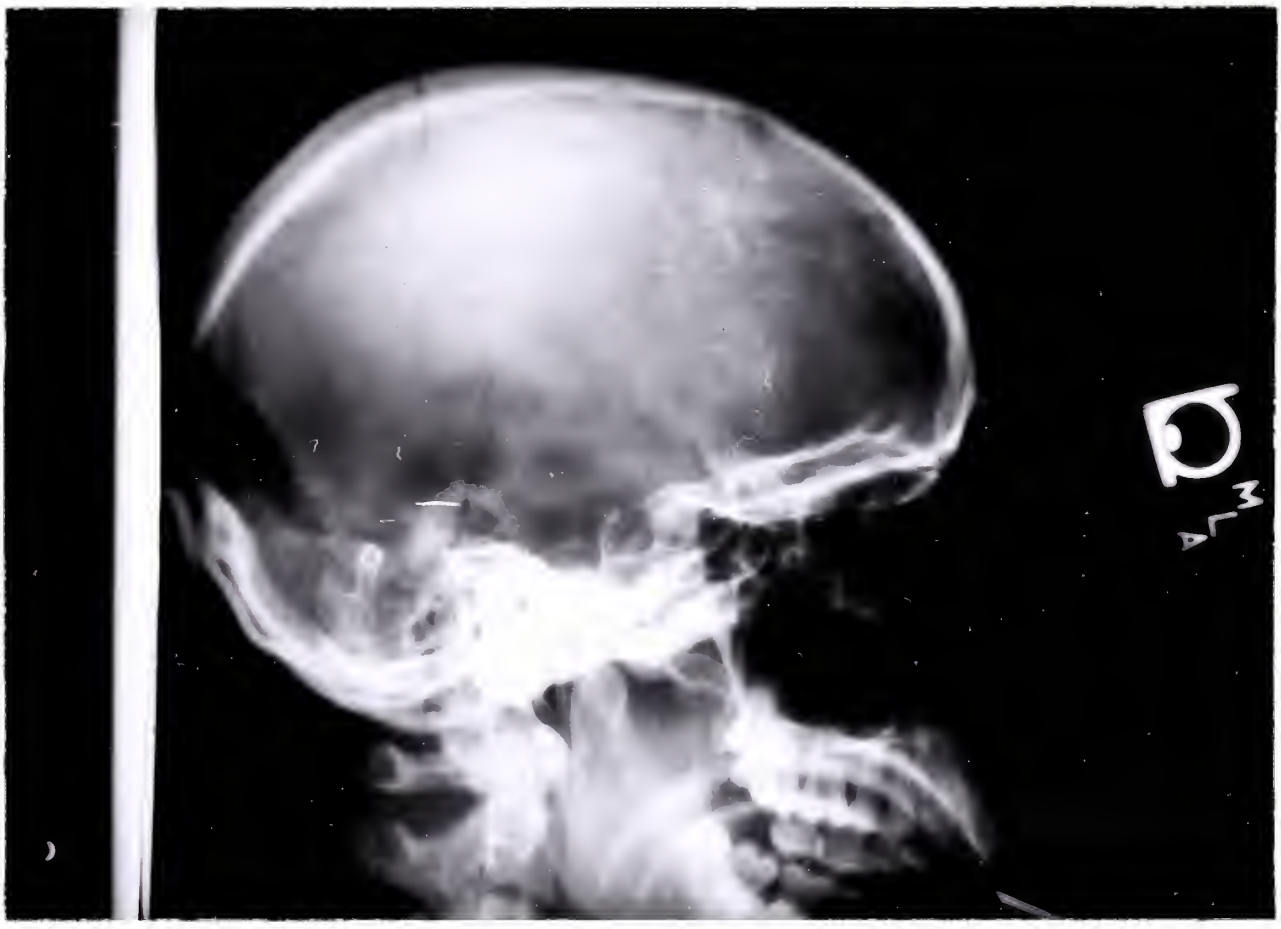
EXAMPLES OF HEAD INJURIES FROM MOTORCYCLE ACCIDENTS



CASE II: Left epidural hematoma requiring evacuation.



CASE II: Fluid in air sinuses, patient supine.



CASE IV: Biparietal skull fracture.

DISCUSSION

The tremendous growth in motorcycle registrations in Connecticut has been paralleled in every state in this country. A similar rapid growth took place in Europe from 1951 to 1960 (12). The significance of this growth as a health problem in the United States has been noted previously (13, 14, 15).

The experience in Connecticut in 1966 indicated that in proportion to their numbers, motorcycles were responsible for more injury and fatal accidents than all other motor vehicles. Pike in 1949 reviewed 579 accidents of the British military involving motorcycles and demonstrated a higher injury-accident rate with motorcycles than with any other service vehicle (17). Starks et al. stated that in Britain the personal injury accident rate is about twice that for automobiles, and that the chance of a motorcyclist being killed per mile ridden is 20 times that of the chance of a car driver being killed (16). His data supporting these conclusions are not presented.

The marked seasonal variation in incidence of motorcycle accidents as seen in 1966 in Connecticut was also recently noted in Maine (13) and apparently had been described in 1952 in Britain by Starks in an unpublished report cited by Bothwell (12). The explanation for the summer peak has not been proved; however, it is most likely that the numbers of miles ridden during the winter months are much fewer than during the summer, perhaps due to the discomfort of exposure to freezing winds and the driver's recognition of the dangers of motorcycling on icy or snowy roads. It is quite possible that per mile ridden winter may be the peak season for motorcycle mishaps. Starks et al. (16) again without reviewing the raw data, claim that motorcycles are about 10 times more likely to be involved in personal injury skidding accidents than are cars. Pike (17) showed little seasonal variation in his series of accidents in the British military, but again, the numbers of miles driven during the respective seasons is not known.

Collisions of motorcycles with other motor vehicles were the most common type of motorcycle accident in Connecticut. These collisions resulted in the greatest number of personal injuries and serious injuries, and accounted for 43.5% of the total fatalities. Pike (17) showed that about 50% of his 579 accidents and 11 of the 16 fatal accidents involved other motor vehicles. Gissane and Bull (18) reviewed 34 motorcycle deaths in Birmingham, England, of which 24 resulted from mishaps with other motor vehicles. In the series by Dillihunt et al. (13) 42% of persons injured had collided with automobiles. Gustilo et al. (14) reported 38.4% of 46 accidents resulted from motorcycle-car collisions.

Accidents with other motor vehicles at intersections accounted for 35% of the total non-injury, injury and fatal motorcycle accidents in Connecticut. Pike (17) showed that 30% of his series of accidents and fatal accidents took place at intersections. All the fatal accidents at intersections in Pike's series, as in Connecticut, involved the vehicles proceeding in opposite directions. He also presented data indicating that more than half of the accidents at intersections occurred with vehicles traveling in opposite directions, as was also true in 1966 in Connecticut.

About 17% of Pike's series occurred between vehicles not at intersections, although 7 of his 16 fatal accidents transpired in this way. In Connecticut 26% of accidents and 4 of the 23 total accidents resulted from this type of collision. As in Connecticut, accidents involving vehicles traveling in the same direction not at intersections were more numerous than those where the vehicles were proceeding in opposite directions.

No comparative statistics are available for accidents in which motorcycles ran off the road. This type of mishap was seen to be relatively infrequent but extremely severe with respect to personal injury and fatality in the Connecticut series. Gissane and Bull (18) do not report the total

incidence of this kind of accident, but ascribe 5 of the 34 Birmingham fatalities to "violent contact with road furniture, lamp posts, walls,... fenses and...the kerb."

Connecticut motorcycle accidents involving pedestrians were infrequent, caused no fatalities and relatively fewer serious injuries than any other type of accident. Motorcycles, comprising 1.36% of total registered vehicles in 1966, participated in accidents causing injury to 21 pedestrians, less than 1% of the 2254 pedestrians injured by all other vehicles. This finding is at variance with the report by Starks et al. (16) that in relation to their numbers on the road motorcycles are the greatest source of injury to pedestrians of all ages. Here again, the data on which this conclusion is based are not presented.

Most motorcycle accidents in Connecticut occurred in clear weather, on dry roads and in daylight. Although the same finding is true for all motor vehicles in the state, relatively more motorcycle accidents transpired under these conditions than mishaps of other motor vehicles. Most likely this finding is related to total miles driven under the various weather, road and lighting conditions. Similarly weekend days show the highest incidence of traffic accidents of all types compared to week days, presumably because of the increased exposure to accident situations with more driving.

A striking feature of the 1966 Connecticut record is that very few accidents happened on the high-speed limited access highways, and none of these mishaps was fatal. This record may reflect a hesitation on the part of the driver to use these roads, as well as relatively little interstate or long-distance travel by motorcycles. In addition these roads contain relatively safe intersections, good visability and few obstacles adjacent to the roadway. Rural routes were much more hazardous. The 16.5% of accidents on State and U.S. routes accounted for nearly half of the motorcycle fatalities,

and probably indicate higher speed accidents as well as delayed care. Most accidents occurred on city streets, although proportionately fewer of these mishaps were fatal compared to the rural accidents.

The circumstances contributing to motorcycle accidents were discussed by Pike (17), who showed 72.5% of accidents involved some causative feature. In Connecticut 72% of accidents included a contributory circumstance. 3 of the 16 fatal accidents in Pike's series implicated excessive speed. In Connecticut, 6 of 23 fatal mishaps were attributed to speeding. Mechanical defects, implicated in less than 1% of accidents in Connecticut, were sited in 7.4% of mishaps studied by Pike in 1949. The difference must be due to improvements in motorcycle technology.

Driving under the influence of alcohol was present in 2 fatal motorcycle accidents in Connecticut. Drinking was implicated in only about 1% of all accidents and 1.2% of injury accidents. Bothwell (12) claims the Swiss attribute 8.9% of motorcycle fatalities to drinking. Cassie and Allen, however, studied 114 motorcycle accidents causing injury to the driver and described elevated blood alcohol levels in 29.8% (19). Pike does not mention drinking as a causative feature.

The problem of inexperience of the motorcycle driver was not investigated in the present study. There is strong evidence to indicate that inexperience is a significant feature of many motorcycle accidents. Pike (17) implicated inexperience in 13.3% of accidents. Gustilo et al. (14) claim that of 70 injured cyclists questioned, 20% were riding the motorcycle for the first or second time, and that 70% had either rented or borrowed the machine. Scott and Jackson (20) and Starks et al. (16) have shown that riders with less than 6 months experience have twice as many accidents as those with more.

The most distressing feature of motorcycle accidents is the segment of the population most severely affected; namely, males between the ages of 16

and 24. The great majority of motorcycle injuries and fatalities affect this group, as the experience in Connecticut in 1966 clearly demonstrates. Dillihunt et al. (13) and Gustilo et al. (14) show a similar age distribution among their series of accidents. Starks et al. (16) reported 34 persons killed in motorcycle mishaps of which 18 were between the ages of 16 and 22 years. Scott and Jackson (20) claim that a teenage boy has a 2% chance of being killed or injured seriously for each year he owns and operates a motorcycle. Lee (21) discussing the increase in motorcycle injuries and fatalities in Britain from 1951-1960, called the impact on this age group an epidemic, being rapid in onset and affecting a substantial portion of the population at risk. Drye (15) considers the recent experience in this country to be an epidemic of trauma.

The head and the extremities were the predominant sites of injury from motorcycle accidents in 1966 in Connecticut. Unlike automobile accidents, injuries to the torso appeared to be relatively infrequent. A review of motorcycle injuries presented by Pike (17), Bauer (22), Dillihunt et al. (13) and Gustilo et al. (14) reveals the same pattern of injuries as seen in the New Haven sample. Pike, studying injuries on British roadways, noted a greater incidence of injuries on the right side of the body, and postulated that this was due to exposure of the right side to oncoming traffic. The New Haven sample reveals more left-sided than right-sided injuries, and Pike's explanation may be quite true. A second possible explanation may be found in an engineering difference between British and other motorcycles, including European, Japanese and American machines. The latter motorcycles have the braking pedal located on the right side, and on stopping the left foot is put on the road and the machine leans to the left. In an emergency braking situation the tendency might be for the motorcycle to fall to the left side. With a left-sided brake pedal on the British machines, a fall to the right

may occur under these circumstances.

Head injury has long been cited as the principal cause of death in motorcycle accidents. In 1941 Cairns (23) reviewed 149 motorcycle deaths, showed that 85 resulted from head injury alone, and 17 in which other injuries were present but head injury dominated the clinical picture. Head injury was described as the cause of death in all of Pike's fatalities (17), 80% of Bauer's fatalities (22), both of the fatalities described by Gustilo et al. (14), 22 of the 34 motorcycle deaths examined by Gissane and Bull (18), all of the three deaths reported by Dillihunt et al. and the one fatality in the New Haven sample.

Cairns and Holbourn studied 96 cases of head injury from motorcycle mishaps in 1943 and showed that frontal injuries were most common and vertex injuries least common, and that temporal injury was most serious and occipital least serious (24). These results were important for the design of effective crash helmets for cyclists. Rawlins (25) discussed the mechanisms of traumatic brain injury and the design of helmets, and concluded that no crash helmet could make a direct impact at 50 miles per hour survivable. The effectiveness of crash helmets in significantly reducing the numbers of deaths and severity of head injuries from motorcycle accidents was described by Lewin and Kennedy (26) and Starks et al. (16). Ryan showed the relative ineffectiveness of helmets which do not adequately protect the frontal and temporal regions of the skull (27).

THE POST-ACCIDENT MOTORCYCLE

CONCLUDING REMARKS

As motorcycle registrations continue to increase, the number of persons killed and injured on these vehicles will increase. An urgent need exists to curtail this mortality and morbidity, especially to the young adult population most severely involved. A survey of the Connecticut motorcycle accidents may serve to demonstrate the nature and magnitude of the current problem.

Occasionally the suggestion is made that motorcycles should be outlawed. This radical measure, though it would certainly obliterate the problem, would most likely prove politically unfeasible. Prohibition of the use of motorcycles could be effected by private institutions, such as universities and colleges, and could thereby focus directly on a significant portion of the population which appears most at risk. Such prohibition, however, would be ineffective during the seasonal peak of accidents, injuries and fatalities. Since automobiles still kill and injure more people in the 16-24 year old group, the argument could be raised that banning motorcycles reflects an inconsistent reasoning.

A de-emphasis of the glamour of motorcycling, as presented through advertising media, could help to reduce the number of young persons interested in owning the vehicle. Advertising of motorcycles should call attention to safe motorcycle driving, including the use of helmets, and should not stress the speed, thrills or status to be enjoyed.

Various legislative measures could certainly result in a decrease in death and injury from mishaps with motorcycles. Already in effect in several states are laws for the compulsory wearing of helmets and separate motorcycle licensing. The effectiveness of helmets cannot be disputed. Presumably licensing should eliminate the totally inexperienced motorcycle driver from the roads. Licensing must be based on driver testing. Hopefully these tests

would include trials on various types and conditions of raod surface and traffic. The motorcycle license should be valid only for a particular vehicle, since there is often variability in the operative procedures among the different makes of cycles, particularly in gear-shifting. Such restrictions are presently in effect for automobile drivers. Passengers, who may not appreciate the forces of balance in driving a motorcycle, should not be permitted.

At the present time virtually no formal courses are available for instruction in operation of a motorcycle. The novice motorcyclist cannot obtain driver training which presents in organized fashion good driving practices. Similarly, automobile driver training lacks instruction about the capacities of the motorcycle on the road, and the ways for safe interaction between cars and motorcycles. Progress in these areas of driver training could be of great benefit in reducing motorcycle accidents.

The most undesirable feature of the motorcycle from the health standpoint is the nearly total lack of protection from injury to the motorcyclist. Only the head can be packaged, by means of a helmet. To prevent other injuries by packaging would destroy the essential nature of the vehicle, if not create a relatively unstable machine. Bothwell has proposed that the extensive use of roll bars with the confinement of the cyclist to his vehicle by safety straps might prevent many fatalities and serious injuries (28). He has suggested motorcycle collision studies with anthropomorphic dolls, as used in automobile crash testing. Such data could indeed provide valuable information for design of a safer vehicle.

The most important measure to reduce motorcycle accidents is basic, safe driving. This is the key to the reduction of all kinds of traffic accidents. Adherence to highway rules and regulations, and "defensive driving" at all times would save more lives and prevent more injuries than any other measure for motorcycle control.

APPENDIX

The following data was obtained with the assistance of the Connecticut Department of Motor Vehicles. The material presented summarizes the 1966 reported motorcycle accidents. In Connecticut report of traffic accidents to the Department of Motor Vehicles is mandatory if there is over $200 in damage or any personal injury involved.

TABLE I

Numbers of Motorcycles
Annual Summaries in Connecticut, 1962-1966

	Registration	Accidents	Injury Accidents	Fatal Accidents
1962	5762	377	296	7
1963	5911	346	282	16
1964	9484	411	323	8
1965	12,969	832	670	20
1966	21,673	1174	980	24

TABLE II

Numbers of Motorcycles involved in Accidents by Month, 1966

	All Accidents		Injury Accidents		Fatal Accidents	
	Number	% Total	Number	% Total	Number	% Total
January	11	0.9	11	1.1	0	0
February	7	0.6	7	0.7	0	0
March	57	4.8	45	4.6	0	0
April	103	8.8	83	8.5	1	4.2
May	163	13.9	140	14.3	3	12.5
June	199	17.0	168	17.2	7	29.2
July	188	16.0	162	16.5	2	8.3
August	177	15.1	148	15.1	6	25.0
September	119	10.2	97	9.9	2	8.3
October	98	8.3	75	7.6	2	8.3
November	44	3.7	36	3.7	1	4.2
December	8	0.7	8	0.8	0	0
TOTAL	1174	100.0	980	100.0	24	100.0

TABLE III

Total Numbers of Other Motor Vehicles
Excluding Motorcycles in Accidents,
Injury Accidents and Fatal Accidents, by Month, 1966

	All Accidents	Injury Accidents	Fatal Accidents
January	8919	3153	37
February	9715	2801	42
March	8328	2752	32
April	8396	2924	48
May	8901	3172	41
June	8408	2893	40
July	8314	2956	35
August	7205	2879	48
September	9070	3123	41
October	9606	3379	51
November	9701	3342	41
December	13,922	4222	56
Unaccounted	2000	--	10
TOTAL	112,495	37,596	522

TABLE IV

Type of Accident

	Number of Accidents				Number Injured*			
	Total	Fatal	Non-Fatal	Killed	Total	A	B	C
Pedestrian	21	0	21	0	29	14	6	9
Other Motor Vehicle	715	10	705	10	715	347	246	122
Bicycle	12	0	12	0	18	5	13	0
Animal	44	0	44	0	48	21	21	6
Fixed Object	61	1	60	1	61	32	22	7
Overturned in Road	114	3	111	4	125	50	59	16
Other Non-Collision	59	0	59	0	59	26	23	10
Ran Off Road	122	9	113	9	122	72	36	14
Other Object	4	0	4	0	3	2	1	0
TOTAL	1152	23	1129	24	1180	569	427	184

*A - Bleeding wound, distorted member, any condition requiring the victim to be carried from the scene

B - Other visible injuries such as bruises, abrasions, swellings, limping or any other painful movement

C - Complaint of pain without visible signs of injury or momentary unconsciousness

TABLE V

Accidents Between a Motorcycle and Another Motor Vehicle at Intersections

	Total	Fatal Accidents	Injury Accidents
One Entering at Angle	168	1	146
Same Direction			
Both going straight	15	0	12
One turn, one straight	55	0	45
One stopped	26	0	17
All others	10	0	6
Opposite Direction			
Both going straight	12	1	10
One left turn, one straight	106	5	94
All others	10	1	1
Not Stated	2	1	1
TOTAL	404	8	341

TABLE VI

Accidents Between a Motorcycle and Another Motor Vehicle Not at Intersections

	Total	Fatal Accidents	Injury Accidents
Going in Opposite Directions	37	0	33
Going in Same Direction	51	1	33
One Parked	32	0	16
One Stopped	32	0	23
One Entering Parked Position	4	0	2
One Leaving Parked Position	6	0	5
Entering Driveway of Alley	89	1	70
Leaving Driveway or Alley	38	0	30
Not Stated	13	2	6
TOTAL	302	4	218

TABLE VII

Motorcycle Accidents Involving
Two or More Other Motor Vehicles

	Total	Fatal Accidents	Injury Accidents
At Intersections	9	0	9
Not at Intersections	14	0	13
TOTAL	23	0	22

TABLE VIII

Motorcycle Accidents not Involving
Another Motor Vehicle or Pedestrians

	Total	Fatal Accidents	Injury Accidents
At Intersections			
Collision with non-motor vehicle	5	0	5
Collision with fixed object	14	0	14
Overturned in road	43	2	37
Left road	32	1	28
Not at Intersections			
Collision with non-motor vehicle	9	0	9
Collision with fixed object	43	1	35
Overturned in road	66	0	63
Left road -			
At curve	55	4	50
Straight road	32	3	25
Fell from moving vehicle	53	0	49
Not Stated	50	0	43
TOTAL	402	11	358

TABLE IX

Weather Conditions

	Total	Fatal Accidents	Injury Accidents
Clear	1039	21	870
Rain	55	1	46
Snow	2	0	2
Fog	6	0	5
Not Stated	50	1	37
TOTAL	1152	23	960

TABLE X

Light

	Total	Fatal Accidents	Injury Accidents
Daylight	796	10	671
Dawn or Dusk	40	1	34
Darkness	315	12	254
Not Stated	1	0	1
TOTAL	1152	23	960

TABLE XI

Road Surface

	Total	Fatal Accidents	Injury Accidents
Dry	1032	22	861
Wet	80	1	68
Snow-Ice	4	0	4
Not Stated	36	0	27
TOTAL	1152	23	960

TABLE XII

Traffic Control

	Total	Fatal Accidents	Injury Accidents
Stop Sign	134	3	116
Stop-Go Signal	128	0	107
Officer or Watchman	6	0	4
RR Gate of Signal	3	1	2
Other	105	6	83
None or Not Stated	776	13	648
TOTAL	1152	23	960

TABLE XIII

Kind of Location

	Total	Fatal Accidents	Injury Accidents
Apartments, Stores Factories	546	11	440
One-Family Homes	449	8	386
Farms, Fields	59	2	50
No Marginal Development	91	2	79
Not Stated	7	0	5
TOTAL	1152	23	960

TABLE XIV

Day of the Week

	Total	Fatal Accidents
Sunday	204	4
Monday	142	5
Tuesday	133	2
Wednesday	112	1
Thursday	155	1
Friday	191	4
Saturday	215	6
TOTAL	1152	23

TABLE XV

Time of Day

	Total	Fatal Accidents
AM:		
Midnight	29	2
1:00	34	5
2:00	8	1
3:00	2	0
4:00	2	0
5:00	0	0
6:00	14	0
7:00	23	0
8:00	17	0
9:00	13	1
10:00	26	0
11:00	35	0
PM:		
Noon	65	0
1:00	57	0
2:00	77	1
3:00	94	1
4:00	113	3
5:00	120	0
6:00	83	2
7:00	87	1
8:00	87	4
9:00	59	1
10:00	56	1
11:00	49	0
Not Stated	2	0
TOTAL	1152	23

TABLE XVI

Type of Road

	Accidents			Persons	
	Total	Fatal	Non-Fatal	Killed	Injured
Controlled Access Highway	8	0	8	0	10
State Routes	112	7	105	7	115
U.S. Routes	79	3	76	3	84
Interstate	15	0	15	0	23
City Streets	938	13	925	14	948
TOTAL ALL ROUTES	1152	23	1129	24	1180
Total Urban	964	14	950	15	979
Total Rural	188	9	179	9	201

TABLE XVII

Contributing Circumstance

(from police reports)

	Total	Fatal Accidents	Injury Accidents
Speeding	88	6	72
Failed to Yield Right of Way	174	1	156
Drove to Left of Center	65	3	56
Improper Overtaking	61	1	44
Passed Stop Sign	16	0	16
Disregarded Traffic Signal	11	0	9
Followed Too Closely	83	1	61
Made Improper Turn	85	4	73
Other Improper Driving	219	3	181
Inadequate Brakes	6	0	5
Improper Lights	5	0	4
Under Influence of Alcohol	16	2	12
TOTAL	829	21	689

TABLE XVIII

Ages of the Drivers of Vehicles in Motorcycle Accidents

	Total	Fatal Accidents	Injury Accidents
15 or Younger	2	0	1
16	82	0	62
17	168	1	141
18-19	374	9	310
20-24	511	10	439
25-34	288	5	239
35-44	166	5	140
45-54	121	3	97
55-64	75	1	55
65-74	37	0	31
75 or Older	14	0	13
Not Stated	72	1	42
TOTAL	1910	35	1570

TABLE XIX

Sex of Driver

	Total	Fatal Accidents	Injury Accidents
Male	1621	33	1347
Female	229	1	188
Not Stated	60	1	35
TOTAL	1910	35	1570

TABLE XX

Residence of Drivers

	Total	Fatal Accidents	Injury Accidents
Local	1058	21	888
Residing Elsewhere in Connecticut	690	12	561
Non-Resident of Connecticut	98	1	83
Not Stated	64	1	38
TOTAL	1910	35	1570

TABLE XXI

Age and Sex of the Casualties

	Killed			Injured		
	Total	Male	Female	Total	Male	Female
0-4	0	0	0	1	1	0
5-9	0	0	0	10	8	2
10-14	0	0	0	30	19	11
15-19	7	6	1	497	424	73
20-24	7	7	0	400	372	28
25-34	6	5	1	156	140	16
35-44	2	2	0	38	30	8
45-54	1	1	0	25	19	6
55-64	1	1	0	14	10	4
65-74	0	0	0	1	0	1
Over 75	0	0	0	2	2	0
Not Stated	0	0	0	6	4	2
TOTAL	24	22	2	1180	1029	151

TABLE XXII

Motorcycle Accident Injuries to 50 Persons in New Haven, 1966

Head and Neck

Type	Number
Abrasion face	9
Laceration forehead	9
Cerebral concussion	8
Laceration nose	4
Fractured skull	3
Fractured nasal bones	2
Laceration lip	2
Laceration chin	2
Laceration cheek	1
Laceration temporal	1
Laceration parietal	1
Epidural hematoma	1
Cerebral contusion	1
Broken tooth	1
TOTAL	45

Left Lower Extremity

Type	Number
Abrasion knee	9
Abrasion leg	4
Abrasion foot	4
Fractured femur	4
Abrasion ankle	3
Laceration knee	2
Hematoma thigh	1
Hematoma leg	1
Abrasion thigh	1
Fractured tibia	1
Fractured hallus	1
Laceration ankle	1
Abrasion hip	1
Fractured tarsal	1
Contusion knee	1
TOTAL	35

Left Upper Extremity

Type	Number
Abrasion arm	6
Laceration arm	3
Fractured radius	2
Abrasion shoulder	2
Abrasion elbow	2
Abrasion hand	2
Fractured ulna	1
Fractured metacarpal	1
Acromioclavicular Separation	1
Contusion forearm	1
Contusion hand	1
Abrasion wrist	1
Fractured proximal phalanx	1
Abrasion thumb	1
Contusion thumb	1
TOTAL	26

Right Lower Extremity

Type	Number
Abrasion knee	6
Abrasion ankle	6
Laceration knee	3
Abrasion leg	3
Contusion thigh	1
Contusion foot	1
Abrasion thigh	1
Laceration leg	1
Laceration foot	1
Contusion leg	1
TOTAL	24

TABLE XXII (continued)

Right Upper Extremity

Type	Number
Laceration hand	3
Abrasion hand	3
Abrasion arm	2
Abrasion elbow	2
Laceration wrist	2
Fractured olecranon	1
Fractured acromium	1
Dislocated PIP joint	1
Laceration elbow	1
Contusion shoulder	1
TOTAL	17

Chest, Abdomen and Back

Type	Number
Pulmonary contusion	2
Pulmonary emboli	2
Abrasion chest	2
Fractured rib	1
Contusion chest wall	1
Abrasion, lumbar	1
Abrasion, epigastric	1
TOTAL	10

Pelvis

Type	Number
Fractured pelvic ramus	1
Contusion pelvis	1
TOTAL	2

REFERENCES

1. Oliver, Smith Hempstone. (1953) Catalog of the Cycle Collection of the Division of Engineering United States National Museum, Bulletin 204 (1953) Smithsonian Institute, Washington, D.C.; U.S. Government Printing Office, Washington.

2. Caunter, Cyril F. The History and Development of Cycles, London, H.M. Stationery Office, 1955.

3. Velocipede, New York: Hurd and Haughton Co., 1869.

4. Oliver, Smith Hempstone. Automobiles and Motorcycles in the United States National Museum (1957), Smithsonian Institution, Washington.

5. Motorcycles in the United States, U.S. Government Printing Office: 1967 - 0 - 240 - 986. Public Health Service.

6. New York Times, July 29, 1966, 38: 3.

7. Esquire Magazine, November, 1965, 64: 138-9.

8. New York Times, March 13, 1966, X 19: 1.

9. New York Times, August 22, 1965, III 1: 5, 7.

10. New York Times, February 27, 1967, 31: 6.

11. New York Times, July 21, 1966, 43: 2.

12. Bothwell, P.W. Practitioner (1962), 188: 474-488.

13. Dillihunt, Richard C.; Maltby, George L.; Drake, Emerson H.; Journal of the American Medical Association (1966) Vol. 196 No. 12: 93.

14. Gustilo, Ramon B.; Foss, Donald L.; Leslie, William R.; Telander, Robert L.; Minnesota Medicine (1965), 48: 489-491.

15. Drye, James C. Journal of Trauma (1965), 5: 823-825.

16. Starks, H.J.H.; Garwood, F.; Jeffcoate, G.O.; Smeed, R.J. International Road Safety and Traffic Review (1961) Vol. IX No. 4: 5-12.

17. Pike, D.F. Bayly. Road Research Technical Paper No. 13, H.M. Stationery Office: London, 1949.

18. Gissane, W.; and Bull, J. British Medical Journal (1961), i, 1716.

19. Cassie, A.B.; and Allen, W.R. British Medical Journal (1961), ii, 1668.

20. Scott, C. and Jackson, S. (1960) Accidents to Young Motor Cyclists; A Statistical Investigation, London.

21. Lee, J.A.H. Proceedings of the Royal Society of Medicine (1963), 56: 365.

22. Bauer, K.H. Ciba Symposium (1957), 5: 148.

23. Cairns, H. British Medical Journal (1941), ii, 4213.

24. Cairns, H. and Holbourn, H. British Medical Journal (1943), i, 591.

25. Rawlins, J.S.P. Lancet (1956), ii, 719.

26. Lewin, W. and Kennedy, W.F.C. British Medical Journal (1956), i, 4978.

27. Ryan, G.A. New England Journal of Medicine (1967) Vol. 276, No. 19: 1006.

28. Bothwell, P.W. Lancet (1960), ii, 807.

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